Urban 3D Models: What's underneath? Handheld Augmented Reality for Subsurface Infrastructure Visualization

Gerhard Schall[1], Erick Mendez[1], Sebastian Junghanns[2], Dieter Schmalstieg[1]

[1] Graz University of Technology, Institute for Computer Graphics and Vision,
Inffeldgasse 16a, A-8010 Graz, Austria
{schall | mendez | schmalstieg}@icg.tugraz.at
[2] GRINTEC GmbH, Maiffredygasse 4/III, A-8010 Graz, Austria
sebastian.junghanns@grintec.com

Abstract. Handheld outdoor augmented reality requires georeferenced models of the environment to present world-registered overlays to a mobile user. We have developed a handheld augmented reality setup combining multiple sensors built around an Ultra-Mobile PC. We present an outdoor application visualizing subsurface infrastructure in 3D extracted from geodata sources.

Keywords: Handheld Geospatial Augmented Reality, Urban 3D Models, Mobile Spatial Interaction, Location Based Services

1 Introduction and Motivation

Advanced ubiquitous environments provide new ways for geospatial interaction. High-resolution 3D models based on geospatial data, complemented with other data sources offer a high potential for new kinds of urban services. At the same time the users face new challenges whilst trying to perceive information among rich information spaces for their particular tasks. In this context, Augmented Reality (AR) is a powerful technique for superimposing registered 3D graphics, like available geospatial data, over the user's view of the real world. AR takes advantage of handheld devices such Ultra-Mobile PC´s (UMPC´s) or smart phones being equipped with additional sensors [3], [6], [7]. Furthermore, AR benefits from the growing popularity of geospatial data, 2D as well as 3D. The live demo we propose uses handheld devices to visualize urban 3D models and subsurface infrastructure registered in 3D.

2 Urban 3D Models

We believe that the availability of geospatial models from real-world data is a key enabling factor for the success of applications for handheld devices. Handheld AR requires highly accurate geospatial databases describing the surrounding environment. In [2] Höllerer and Feiner mentioned that there are significant research problems involved in the modeling task of urban 3D models. Consider, for example, the task of completely modeling an urban area, down to the level of electric circuits in walls of buildings. Schmalstieg et al. [5] presented an AR modeling pipeline to create, manage and use complex AR models. They investigate how AR models must be structured so that they are sufficiently flexible to address a wide range of AR applications and lend themselves to real-time use in location based applications.

The most effective way of creating large and accurate urban 3D models for AR is achieved by querying a geospatial database running on a Geo-database management system (GeoDBMS). An arbitrary selection of data of any spatial extent can be retrieved on demand. Examples of services providing online access to geospatial data sources are Web Feature Services (WFS) or servers for virtual globe browsers such as *Google Earth* or *MS Virtual Earth*[1]. Since many consistent geospatial databases are already in productive use in areas such as cadastral survey or utility asset management, AR can largely benefit from this up-to-date data.

The user's outdoor position and orientation is given in a user reference system by GPS and inertial tracking. Since there can be a number of different reference systems involved, a common absolute reference system must be used for the urban 3D model as well as the tracking system (see Figure 1).

We have acquired original subsurface infrastructure data of the conference venue. Three different layers of subsurface infrastructure – consisting of sewer, water mains and electricity lines – around the congress center in Innsbruck are shown in the demo.

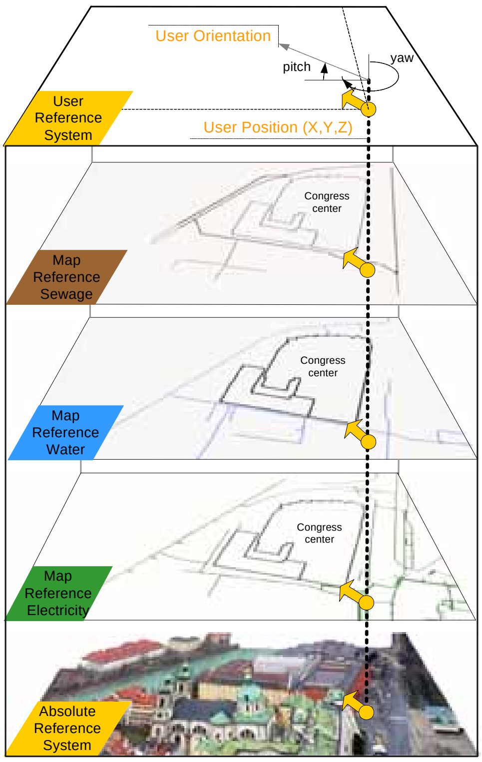

Figure 1: **Matching of the user and map reference system to an absolute reference system**

3 Handheld Augmented Reality

We have built a prototype handheld setup, consisting of a Sony UX UMPC and sensors attached to an acrylic

[1] http://earth.google.com/ and http://www.microsoft.com/virtualearth

mount (see Figure 2) including a uEye USB camera for the required video see-through metaphor.

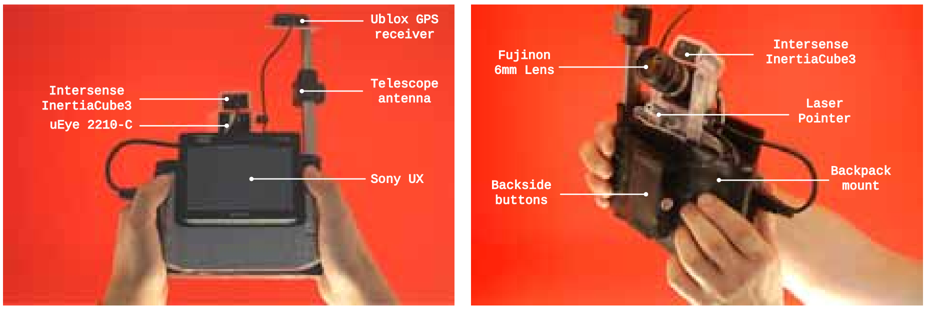

Figure 2: Front view (left) and back view (right) of the handheld AR setup

Tracking of the user is provided by an EGNOS (European Geostationary Navigation Overlay Service) enabled GPS sensor merged with orientation estimates delivered by an InterSense InertiaCube3 (Inertial Measurement Unit). Hence, a 3G card allows the mobile user to download even large geospatial databases from pervasive servers.

4 Visualization of Urban Subsurface Infrastructure

In this demo we show an augmented reality application, VIDENTE (http://www.vidente.at), tailored to the visualization of subsurface GIS infrastructure [4]. The goal of this application is to provide egocentric visualization of 3D subsurface infrastructure data from geospatial databases providing a variety of dynamic visualization styles, like magic lenses for showing excavations [1]. The semantic information attached to the objects (such as date of construction) allows rendering the objects in the scene differently.

Users are able to roam the surrounding environment of the conference venue in Innsbruck and see the subsurface infrastructure overlaid on top of the video see-through display and therefore get a better understanding of the surrounding. The complete urban 3D model is stored on a server. For true mobility, the handheld device queries this server with its current position to obtain the appropriate part of the urban 3D model. Once the application is fully implemented, the client will only need to access the ubiquitous infrastructure for accessing geospatial content.

An example of a working prototype is given in Figure 3, which depicts a user with the handheld device seeing parts of the urban 3D model superimposed on the real world. Conference participants will be able to experience the presented AR scenario at the conference venue in Innsbruck by using the handheld AR setup.

Figure 3: Tracked outdoor user seeing superimposed AR buildings and subsurface infrastructure (water mains, electricity lines in this example)

5 Conclusion

We have implemented a prototype augmented reality application for visualizing urban 3D models transcoded by a modeling pipeline from existing geospatial databases. Urban 3D models are extended by very useful subsurface infrastructure. This is an important step towards our vision of allowing a mobile user seamless and mobile spatial interaction in a ubiquitous environment to provide location based experiences.

Acknowledgements This work was sponsored by the Österreichische Forschungsförderungsgesellschaft FFG under contract no. BRIDGE 811000 and the Austrian Science Fund FWF under contract no. Y193. We thank GRINTEC GmbH and Innsbrucker Kommunalbetriebe AG for providing the geospatial data.

References

[1] Mendez E., Kalkofen D., Schmalstieg D., "Interactive Context-Driven Visualisation Tools for Augmented Reality," In Proceedings of ISMAR 2006, October 22-25, 2006, Santa Barbara, California, USA. pp. 209-216, 2006

[2] Hallaway D., Höllerer T., Feiner S., Bridging the gaps: Hybrid tracking for adaptive mobile augmented reality in Applied Artificial Intelligence, Special Edition on Artificial Intelligence in Mobile Systems, 25(5), July 2004

[3] Reitmayr G., Schmalstieg D., “Location Based Applications for Mobile Augmented Reality”. Proc. Fourth Australasian User Interface Conference (AUIC), 65-73, 2003

[4] Schall G., Reitinger B., Mendez E., Junghanns S., Schmalstieg D., „Handheld Geospatial Augmented Reality Using Urban 3D Models“, Workshop on Mobile Spatial Interaction in conj. with ACM International Conference on Human Factors in Computing Systems (CHI´07), San Jose, USA, 2007

[5] Schmalstieg D., Reitmayr G., Schall G., Newman J., Wagner D., Ledermann F., Barakonyi I., “Managing Complex Augmented Reality Models,” In IEEE Computer Graphics and Applications (CG&A), Special Issue on 3D Documents, no. 4, July/August 2007, to appear

[6] Schreiner K., “Where We At? Mobile Phones Bring GPS to the Masses”, In IEEE Computer Graphics and Applications (CG&A), May/June 2007, pp 6-11

[7] Wagner D., Schmalstieg D., Handheld Augmented Reality Display, In Proc. of IEEE Virtual Reality, 2006